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(71) Applicant: CATERPILLAR TRACTOR CO.
100 Northeast Adams Street
Peoria Illinois 61629(US)

(72) Inventor: Wilson, Donald E.
10217 North Spring Lane
Peoria Illinois 61615(US)

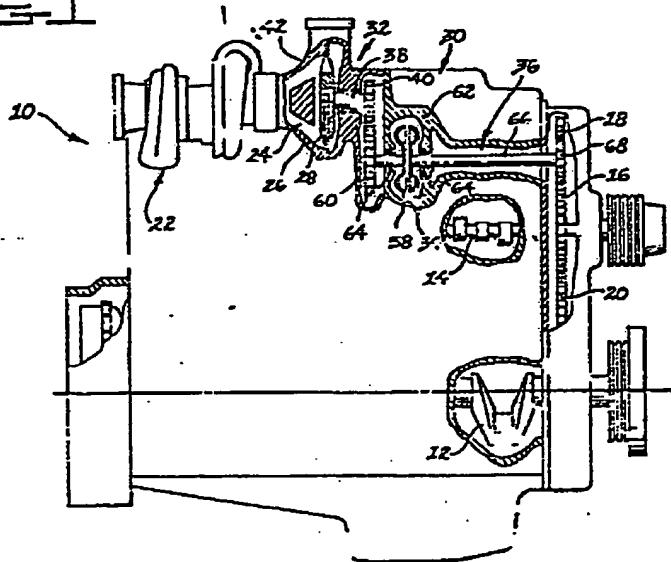
(74) Representative: Brunner, Michael John et al,
GILL JENNINGS & EVERY 53-64 Chancery Lane
London WC2A 1HN(GB)

(54) Turbocompound engine having power turbine output connected to the timing gear.

(57) The invention comprises a turbocompound engine (10) in which power is fed into the timing gears (16, 18, 20) of the engine (10). The mechanism for transmitting power (30) includes a driving mechanism (32), a fluid coupler mechanism (34) and a connecting mechanism (36) attached to the timing gears (16, 18, 20). Thus the disclosed invention uses existing timing gears (16, 18, 20) which are already machined and designed for continual load carrying capacity. The compound portion of the turbocompound engine (10) is located near the front and top of the engine allowing for excellent maintenance and serviceability.

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FIG. 1



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Turbocompound Engine Having Power Turbine
Output Connected to the Timing Gear

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This invention relates generally to engines and more particularly to turbocompound engines.

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The struggle to increase efficiency of internal combustion engines is a constant endeavor of engineers. Turbocompound engines have been known for many years.

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The turbocompound engines of the past have recovered power from the exhaust and transmitted this power back into the engine through the flywheel. The flywheel normally has a pressed on starter gear or ring gear which is used to transmit power from the starter to the crankshaft of the engine enabling rotation of the crankshaft and consequent starting of the engine.

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The loads and forces inputted into this gear are low and infrequent in nature, and therefore do not require a strong gear or accurate tooth profile. The backlash and tooth contact surface of the starter and ring gear are of a low quality due to their short contact times and infrequent load requirements. Analysis has shown that failure would occur causing the engine to malfunction if the power was transmitted through the existing gear teeth on the flywheel starter gear. For this reason the ring gear requires a new tooth design. This new tooth design is more costly and requires a major change.

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Another drawback of feeding power back into the flywheel or rear of the engine comes into play when servicing of the components is required. The flywheel

and connecting components are buried under structural members and difficult to service. For example, in an on highway truck the rear of the engine is located under the cab and in many cases above the axle and front suspension system. Power take-offs and other accessories are also in this immediate area further restricting accessibility to the power input from the turbocompound portion of the engine.

The present invention is directed to
10 overcoming one or more of the problems as set forth
above.

In one aspect of the present invention, an
15 engine includes a crankshaft, a camshaft, a plurality of timing gears drivingly connecting the crankshaft with the camshaft, a turbocharger driven by exhaust from the engine, and a turbine positioned in the flow path of the exhaust exiting the turbocharger to be
20 driven thereby. A means is provided for transmitting power from the turbine to the crankshaft by driving connection with one of the plurality of timing gears.

The turbocompound engine of the present invention overcomes the problem of inadequate gear
25 design by feeding the recovered power from the exhaust back into the existing and structurally sound timing gears. Unlike conventional turbocompound engines which feed recovered exhaust energy into the flywheel at the back of the engine, the components of this invention
30 are near the front of the engine and above the center allowing for ease of service and maintenance.

In the drawings:

Fig. 1 is a side elevational view of one
35 embodiment of the turbocompound engine of the present

invention and having portions broken out for illustrative convenience;

Fig. 2 is a sectionalized view of the bearing arrangement of the driving mechanism as shown in Fig. 5; and

Fig. 3 is a diagrammatic portion of the side elevational view of another embodiment of the turbocompound engine of the present invention;

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Referring initially to Fig. 1 an engine 10 is illustrated. The primary portion of the engine 10 is of conventional design and includes a crankshaft 12, a camshaft 14, and a plurality of timing gears 16, 18, 20. The timing gears 16, 18, 20 drivingly connect the crankshaft 12 with the camshaft 14. Gears 16 and 18 are used to drive accessory equipment such as, a water pump or a hydraulic pump. The gear 20 is an idler gear for transmitting power between the accessory gears 16, 18 and the crankshaft 12. A turbocharger 22 is driven by the exhaust from the engine 10. The exhaust from the turbocharger 22 flows through a passage 24 within a duct 26 and is directed to a turbine 28 positioned in the flow path of the exhaust exiting the turbocharger 22. The exhaust exiting the turbine 28 is emitted to the atmosphere. The turbine 28 as disclosed in this embodiment is an axial turbine 28, however, as an alternative the turbine 28 could be of the radial design.

30 The turbine 28 is connected to a means 30 for transmitting power to one gear 16 of the plurality of timing gears. The transmitting means 30 includes a driving mechanism 32 connected to the turbine 28, a fluid coupler mechanism 34 connected to the driving mechanism 32, and a means 36 for connecting the fluid coupler mechanism 34 to the gear 16.

As shown in Fig. 2, the driving mechanism 32 includes a shaft 38 connected at one end to the turbine 28, a gear 40 attached to the other end of the shaft 38 and connected to the fluid coupler mechanism 34, a housing 42 and a means 44 for supporting the shaft in the housing 42. The supporting means 44 includes a pair of roller bearings 46,48 located in the housing 42 and surrounding the shaft 38. One bearing 46 of the pair of bearings 46,48 is located near the turbine 28 and the other bearing 48 is located near the gear 40. The one bearing 46 is supported in the housing 42 by the squeeze film method and the other bearing 48 is secured by the more conventional tolerance fit with respect to the housing 42. A wave washer 50 is located between the bearing 48 and the housing 42.

In the squeeze film method of mounting the one bearing 46 in the housing 42, a space or an annulus 52 is provided between an outer race 54 and the housing 42. Oil is directed into the annulus 52 through a passage 56 and squeezes past the outer race 54 and the housing 42 draining back to the source.

The fluid coupler mechanism 34 includes a fluid coupler 58 of conventional design, a gear 60 attached to one end of the fluid coupler 58 and meshing with the gear 40 of the driving mechanism 32. A housing 62 surrounds the fluid coupler 58 and the gear 60. A pair of bearings 64 located in the housing 62 support the fluid coupler 58 and the gear 60.

The means 36 for connecting the fluid coupler mechanism 34 to the gear 16 includes a shaft 66 connected to the fluid coupler mechanism 34 and a gear 68 attaches to the shaft 66 at the end opposite the fluid coupler mechanism 34. The gear 68 meshes with the water pump accessory drive gear 16.

An alternate embodiment of a turbocompound engine 10 having the power feed into the timing gear 16 of the present invention is disclosed in Fig. 3. It is noted that the same reference numerals of the first embodiment are used to designate similarly constructed counterpart elements of this embodiment. In this embodiment, however, the means 36 for connecting the fluid coupler mechanism 34 includes a clutch mechanism 70 located between the fluid coupler mechanism 34 and the gear 16. The clutch mechanism 70 is a one way clutch. As an alternative to the one way clutch arrangements, a mechanical or electrical clutch can be used. The clutch mechanism 70 is connected to the output end of the fluid coupler 58. A shaft 72 is attached to the output end of the clutch mechanism 70, and the gear 68 attaches to the shaft 72 at the end opposite the clutch mechanism 70. As an alternate to the disclosed embodiment, the output end of the clutch mechanism 70 could be attached to the gear 68 and the shaft 72 could attach the input end of the clutch mechanism 70 to the fluid coupler 58.

The turbocompound engine 10 can be substituted for any conventional engine application such as for use in earthmoving equipment, generator sets, marine applications and on highway trucks. The internal combustion engine exhaust is used to drive a standard turbocharger 22. The heat energy of the exhaust exiting the turbocharger 22 is directed through the passage 24 in the duct 26 to the turbine 28. The exhaust flows through the axial turbine 28 causing the shaft 38 to rotate at a high rate of speed. The rotating shaft 38 transmits the power to the gear 40 which in turn transmits power to the gear 60 attached

- to the fluid coupler 58. From the fluid coupler 58, the rotational energy is transmitted through the shaft 66 to the gear 68 and to the gear 16 and back through the plurality of timing gears 16,18,20 to the 5 crankshaft 12. Thus, the heat energy of the exhaust which would otherwise be lost is converted to mechanical energy directed back into the timing gears. After the energy has been extracted from the exhaust, the exhaust is discharged to the atmosphere.
- 10 The ratio of the shaft gear 38 to the fluid coupler gear 60 causes a speed reduction to occur. The one bearing 46 of the supporting means 40 absorbs transverse vibrations or oscillations of the shaft 38. The wave washer 50 located between the other bearing 48 15 and the housing 42 establishes a continual preload on the bearings 46,48 and permits snug assembly without the necessity of holding the parts to very close tolerance. The fluid coupler 58 compensates for speed differential and reduces the affect of the torsional 20 vibrations from the engine 10 back to the turbine 28.
- Under normal operating conditions of the engine 10, a high amount of exhaust is emitted and drives the turbine 28. Under low speed conditions of the engine 10, the amount of exhaust may not suffice to 25 drive the turbine 28 at a high rate of speed. The engine 10 under these low speed conditions could drive the connecting means 36 through the timing gear 16, feedback through the fluid coupler mechanism 34 and results in driving the turbine 28.
- 30 As an alternate embodiment to overcome this shortcoming of this low speed operation, the one-way clutch 70 is added to the connecting means 36. The engine 10 and turbocompound components will be disengaged from each other by the one-way clutch 70 and

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under the aforementioned conditions the engine 10 will not feed back through the fluid coupler mechanism 34 and result in driving the turbine 28.

5 The turbocompound engine of this invention uses the existing timing gears 16,18,20 which are already machined and designed for continual load carrying capacity. The compound portion of the turbocompound engine 10 is located near the front and top of the engine 10 allowing for excellent maintenance
10 and serviceability.

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Claims

1. In an engine (10) including a crankshaft (12), a camshaft (14), a plurality of timing gears (16,18,20) drivingly connecting the crankshaft (12) with the camshaft (14), a turbocharger (22) driven by exhaust from the engine (10), and a turbine (28) positioned in the flow path of the exhaust exiting the turbocharger (22) to be driven thereby, the improvement comprising:

means (30) for transmitting power from the turbine (28) to the crankshaft by driving connection with one of the plurality of timing gears (16,18,20).

15 2. The engine (10) of claim 1 wherein said turbine (28) is an axial turbine (30).

20 3. The engine (10) of claim 1 wherein said means (30) for transmitting power includes a driving mechanism (32) connected to the turbine (28), a fluid coupler mechanism (34) connected to the driving mechanism (32) and means (36) for connecting the fluid coupler mechanism (38) to said one of the plurality of timing gears (16,18,20).

25 4. The engine (10) of claim 3 wherein said means (36) for connecting includes a shaft (66) connected to the fluid coupler mechanism (34), and a gear (68) attached to the shaft (66) at the end opposite the fluid coupler mechanism (34), said gear (68) meshing with said one of the plurality of timing gears (16,18,20).

5. The engine (10) of claim 3 wherein said means (36) for connecting includes a clutch mechanism (70) located between the fluid coupler mechanism (34) and said one of the plurality of timing gears (16,18,20).

6. The engine (10) of claim 5 wherein said clutch mechanism (70) is a one-way clutch.

10 7. The engine (10) of claim 3 wherein said driving mechanism (32) includes a shaft (38) connected at one end to the turbine (28), a gear (40) attached to the other end of the shaft (38), a housing (42), and means (44) for supporting the shaft (38) in the housing
15 (42).

8. The engine (10) of claim 7 wherein said means (44) for supporting the shaft (38) in the housing (42) includes a pair of roller bearings (46,48).

20 9. The engine (10) of claim 8 wherein one (46) of said pair of bearings is located near the turbine (28) and the other bearing (48) is located near the gear (40), said one bearing (46) being supported in
25 the housing (42) by the squeeze film method, and said supporting means (44) includes a wave washer (50) located between the other bearing (48) and the housing (42).

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10. The engine (10) of claim 3 wherein said fluid coupler mechanism (34) includes a fluid coupler (58), a gear (60) attached to one end of the fluid coupler (58) and connected to the driving mechanism (32), a housing (62) surrounding the fluid coupler (58) and the gear (60), and a pair of bearings (64) located in the housing (62) supporting the fluid coupler (58) and the gear (60).

10 11. The engine (10) of claim 3 wherein said one of the plurality of timing gears is an accessory water pump gear (16).

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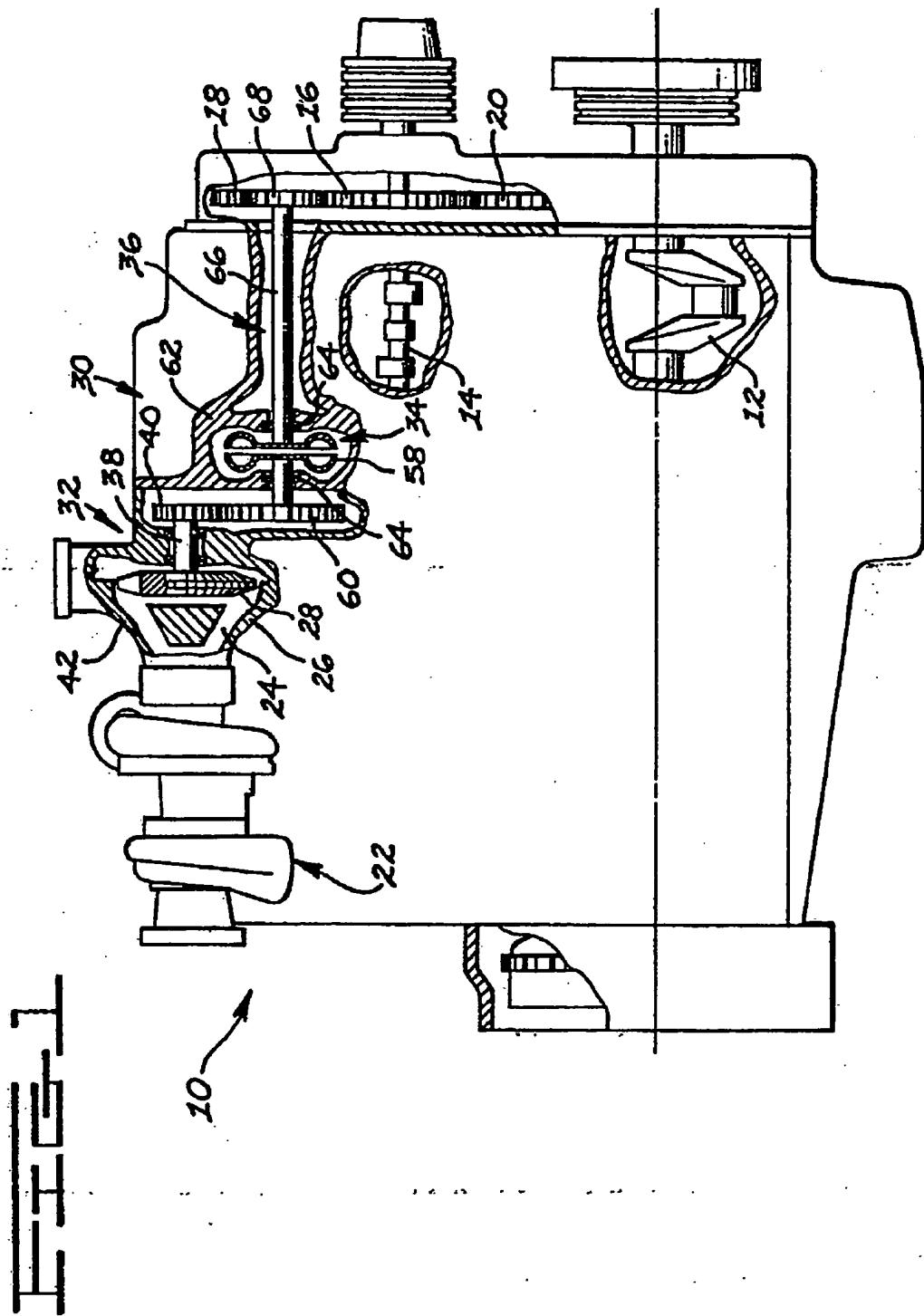
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FIG - 2

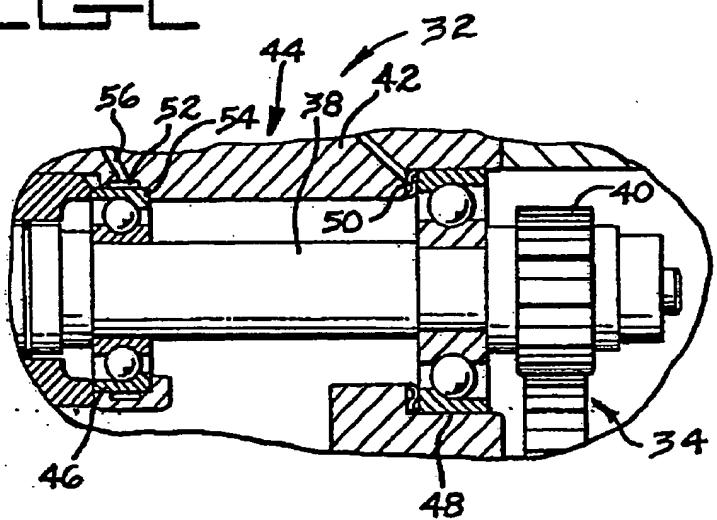
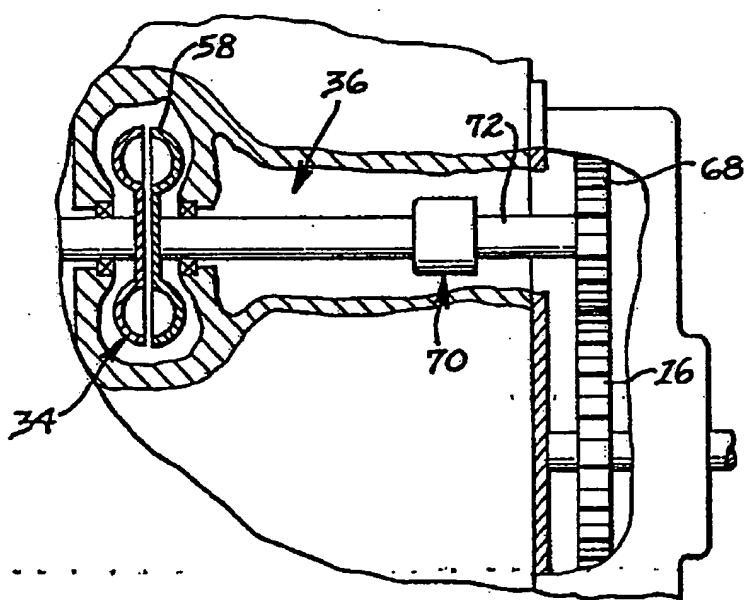


FIG - 3





European Patent
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EUROPEAN SEARCH REPORT

0171882
Application number

EP 85 30 3987

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Y	DE-A- 952 851 (NSU) * Page 1, lines 1-11; figures 1-3; page 2, lines 19-96 * ---	1,2	F 02 B 41/10 F 02 B 67/00 F 02 B 37/00
Y	GB-A- 866 017 (K.H.D.) * Page 1, lines 9-21; page 3, lines 68-96; figures * ---	1-3,7, 8	
Y	US-A-3 050 932 (DAIMLER BENZ) * Column 2, line 48 - column 4, line 62; figure 1 *	3	
A	---	4,-6, 10	
Y	FR-A- 471 200 (MICHaux) * Page 1, line 43 - page 2, line 23; figures *	7,8	TECHNICAL FIELDS SEARCHED (Int. Cl.)
A	---	9	F 02 B F 02 G
A	US-A-1 520 942 (GARRET) * Page 2, lines 11-87; figures 1-5 *	11	
A	GB-A-2 082 682 (MOTOR IBERICA)		
A	US-E- 15 769 (McELRATH)		
The present search report has been drawn up for all claims			
Place of search THE HAGUE	Date of completion of the search 21-10-1985	Examiner KOOIJMAN F.G.M.	
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